AD-A044 519 TRAINING ANALYSIS AND EVALUATION GROUP (NAVY) ORLANDO FLA F/G 5/9
EVALUATION OF MICROFICHE AS AN INSTRUCTIONAL MEDIUM IN A TECHNI--ETC(U)
JUL 77 W A RIZZO

UNCLASSIFIED TAEG-48 NL

1 OF 1
ADA044519


END
DATE FILMED
10-77
DDC

# TAEG

TRAINING ANALYSIS AND EVALUATION GROUP

(12)

TAEG REPORT NO. 48

# EVALUATION OF MICROFICHE AS AN INSTRUCTIONAL MEDIUM IN A TECHNICAL TRAINING ENVIRONMENT



FOCUS ON THE TRAINED MAN



APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION IS UNLIMITED.

JULY 1977

TRAINING ANALYSIS AND EVALUATION GROUP
ORLANDO, FLORIDA 32813

(14) TAEG Report No. 48

(6) EVALUATION OF MICROFICHE AS AN INSTRUCTIONAL MEDIUM IN A TECHNICAL TRAINING ENVIRONMENT

(10) William A. Rizzo

(11) July 1977

Sponsored by

Chief of Naval Education and Training

and the

David W. Taylor Naval Ship Research and Development Center,
Naval Technical Information Presentation Program

(12) 45 p.



(9) Rept. for Sep 76-Jun 77 on Chaos 2.



Alfred F. Smode

ALFRED F. SMODE, Ph.D., Director
Training Analysis and Evaluation Group

Worth Scanland

WORTH SCANLAND, Ph.D.
Assistant Chief of Staff for
Research and Program Development
Chief of Naval Education and Training

407 626

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>TAEG Report No. 48 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>Evaluation of Microfiche as an Instructional Medium in a Technical Training Environment | | 5. TYPE OF REPORT & PERIOD COVERED<br>Phase II<br>Sep 1976 - Jun 1977<br>6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br>William A. Rizzo | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Training Analysis and Evaluation Group<br>Orlando, FL 32813 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS | | 12. REPORT DATE<br>July 1977<br>13. NUMBER OF PAGES<br>50 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report)<br>Unclassified<br>15a. DECLASSIFICATION DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Basic Electricity and Electronics (BE&E) Training
Individualized Instruction
Microfiche Training
Onboard Training
Programmed Instruction
Training Media

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report concludes the second phase of a four-phase study concerning the application of the microfiche medium for onboard training. This study compared the efficiency of using microfiche versus traditional paper copy for training of Basic Electricity and Electronics (BE&E). Thirty experimental trainees completed the BE&E curriculum using training modules republished as microfiche. The school performance of these trainees was compared to a control group (matched by ASVAB scores) using existing modules

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

printed by offset copy. Overall, there was no significant difference in performance between the two groups. For both groups, performance was directly related to aptitude. However, low aptitude trainees using microfiche required significantly more time to complete the curriculum than the corresponding control sub-group. The tabulation of posttraining interview responses indicated no notable user complaints regarding the use of microfiche. Costs associated with using microfiche versus paper copy for training were compared under existing and hypothetical configurations. The two major factors affecting cost were time to complete training and the consumption rate of instructional materials.

## ACKNOWLEDGEMENTS

The support provided by the Basic Electricity and Electronics School, Service School Command, Orlando, Florida, is gratefully acknowledged, especially the cooperation and assistance of TMCS Ralph Comp and FTG-2 Thomas Ferrill.

Appreciation of the efforts of a number of Training Analysis and Evaluation Group personnel is also extended, including the counsel and advice of Dr. Richard Braby, team leader; Dr. Mike Zajkowski for his efforts in refining and editing the presentation of the material; and Dr. William Swope for his advice and inputs to the economic analysis.

TABLE OF CONTENTS

## LIST OF ILLUSTRATIONS



## LIST OF TABLES

# SECTION I

## INTRODUCTION

The increase of military manpower costs in recent years, combined with the fact that approximately half of the enlisted personnel serve for only one tour, has resulted in renewed focus on economizing the Navy's first tour training costs. This condition has stimulated studies to examine the feasibility of shifting a portion of resident, or schoolhouse, training to the onboard environment.

The anticipated expansion of onboard training has necessitated an evaluation of traditional and alternative instructional delivery systems in terms of the unique requirements of the onboard environment. One of the objectives of the David W. Taylor Naval Ship Research and Development Center (NSRDC) Naval Technical Information Presentation Program (NTIPP) is to examine prospective media which may be optimally suited for onboard use. The Training Analysis and Evaluation Group (TAEG), with NTIPP support, is assessing the technical feasibility, economic efficiency, and user acceptance of candidate information delivery systems for onboard training.

A critical requirement in the shipboard environment is space economy. This has resulted in efforts to reduce the quantity of paper documentation needed in support of operations and maintenance. Micrographics have emerged as a viable solution to this data storage problem. In the form of microfiche, the physical volume of paper documentation can be reduced dramatically.

If the volume of instructional materials destined for shipboard use is to increase, commensurate miniaturization of these materials seems inevitable. To assess the feasibility of using microfiche for onboard training, the Chief of Naval Education and Training (CNET) tasked TAEG to compare the use of microfiche with traditional instructional media.

A series of studies are concerned with this objective. The initial effort (TAEG Report No. 35) evaluated human factors considerations in selecting and/or designing microfiche readers for training. A second study (TAEG Technical Memorandum 77-2) compared the use of sound/fiche audio/visual programs with traditional sound/slide programs. The present study examines the effects on learning of microfiche versus paper copy. Another study, currently underway, is evaluating the effectiveness of training modules designed specifically for the microfiche medium and techniques for the efficient production of microfiche-based instructional materials. It is envisaged that this evaluation will be conducted in both classroom and onboard environments. Finally, a set of studies will be conducted concerning human factors, learning effects, and environmental testing using a hand-held, battery-powered microfiche reader, the Personalized Portable Micromedia Display System (PPMDS), which is currently under development at NSRDC.

This total TAEG project will provide NSRDC and CNET with a comprehensive evaluation of microfiche-related hardware and software for potential use in onboard as well as schoolhouse training.

PURPOSE

The purpose of this study was to evaluate the effectiveness of using microfiche as the principal instructional medium in a Navy technical training environment. The use of microfiche versus traditional paper copy was compared in terms of:

1. the effects of medium on time to complete a course of instruction and examination error rate

2. the effects of medium on training as a function of trainee aptitude

3. trainee attitudes concerning the use of microfiche

4. economic considerations of alte, native media.

# SECTION II

# METHOD

## STUDY ENVIRONMENT

The Basic Electricity and Electronics (BE&E) School, Service School Command, Orlando, Florida, served as the study testbed. The BE&E School provides students with the prerequisite training for attendance at more advanced and specialized technical schools. The school is comprised of three learning complexes which accommodate approximately 90 trainees each. The learning complexes are divided into learning centers of approximately 18 trainees. Each learning center has a supervisor who oversees the progress of training, which is individualized and self-paced. In addition to assisting students with their training, the learning center supervisor serves as an interface with the automated records keeping system known as Computerized Managed Instruction (CMI). Virtually all school-related activities of each trainee are recorded by inputs from the learning center supervisor.

Most trainees complete 14 "modules" of instruction covering the fundamentals of electricity and electronics. Appendix A contains this curriculum outline. Each trainee takes 18 module tests, and midpoint and final comprehensive examinations, for a total of 20 segments of instruction. All tests must be passed to a 100 percent criterion. Remedial training and testing are provided until the mastery criterion is reached. Although the training modules are printed on offset copy, all testing is done using microfiche.

## SUBJECTS

Thirty male trainees at the BE&E School completed the 14-module curriculum using training materials republished as microfiche. They ranged in age from 18 to 23 (median = 20) and were all recent graduates of recruit training. Subjects were selected from within three mental aptitude groups. For the purposes of this study, mental aptitude was defined in terms of the combined word knowledge (WK) and arithmetic reasoning (AR) scales of the Armed Services Vocational Aptitude Battery (ASVAB). An examination of recent historical data on 1,000 BE&E trainees revealed that the mean WK + AR score for this group was 115.7 with a standard deviation of 9.35. Based on this distribution, three groups of ten trainees were established using the following aptitude criteria:

| | | | | |
|---|---|---|---|---|
| High | - | WK + AR | > | 125 |
| Medium | - | WK + AR | = | 111-121 |
| Low | - | WK + AR | < | 107 |

There was a between group separation of approximately .5 $\sigma$ to increase the distinction between aptitude categories.

A control group of 30 subjects was selected from the pool of graduates of the BE&E School, Orlando, during the period of the study (September 1976 to March 1977). The experimental and control groups were matched on the basis of combined WK + AR scores. Since the controls were selected at the completion of the study, they had no knowledge of their role in generating experimental data.

## INSTRUCTIONAL MATERIALS

The BE&E modules are published as 14 booklets using offset printing. The lessons in each module are divided into three sections: lesson narrative, programmed instruction, and summary. In addition to the modules, "enrichment materials" are available for trainee use. These materials are in the form of additional readings and sound/slide programs. Trainees have the option of using any or all of the instructional materials; however, experience has shown that the enrichment materials are rarely used.

The 14 BE&E modules were republished on negative image microfiche, in the 98 frame (7 rows X 14 columns) 1/24 X format. All but one of the modules were more than 98 pages, requiring more than one fiche per module, resulting in a total of 30 fiche. The fiche were produced so that no lesson appeared on more than one fiche, eliminating the requirement to change fiche in mid-lesson.

The content of the modules and fiche was identical with one exception--module page numbers were replaced with fiche alphanumeric frame designators corresponding to the 98 image format. In the programmed instruction sections, branching directions were edited to include the appropriate alphanumeric frame designators.

## EQUIPMENT

All trainees (experimental and control) studied in locally-fabricated learning carrels. The carrels used by the experimental group were equipped with Realist/Vantage I microfiche readers with a 24 X lens. Experimental trainees were also issued a Realist/Vantage I reader for their individual use in the dormitory.

## PROCEDURE

Performance data on trainees using microfiche were gathered over a 7 month period from September 1976 to March 1977. There were from six to eight subjects using microfiche at any given time, while the remainder of the trainees in the learning center used traditional paper copy materials. As subjects graduated, they were replaced until the desired total of 30 was reached. The learning center supervisor was instructed to give no special attention to the experimental trainees.

Subjects were given approximately one-half hour of briefing on the purpose of the study, use of the microfiche reader, and the format of the microfiche training modules. All subjects received the same taped briefing (appendix B) and practice fiche exercises under the supervision of the experimenter. They were advised that dormitory study was totally discretionary and that the extra reader was assigned so as not to deny that option.

Upon completion of the curriculum, subjects were given a structured interview by the experimenter to solicit responses regarding operational factors, microfiche training modules, physical comfort, study habits, attitudes, and recommendations. The format for this interview is in appendix C.

DESIGN

Thirty experimental and thirty control subjects were matched on the basis of ASVAB scores representing high, medium, and low aptitude levels. The effects of medium (microfiche versus paper), aptitude (high, medium, and low), and segment of instruction (1 - 20) on the dependent variable, time to criterion, were analyzed by a 2 X 3 X 20 factorial design. The effects of medium (microfiche versus paper) and aptitude (high, medium, and low) on a second dependent variable, error rate, were analyzed by a 2 X 3 factorial design. Error rate was defined as the combined number of errors on the midpoint and final comprehensive tests.

## SECTION III

## RESULTS

Results in this section are presented in terms of time to criterion, errors, and interview responses, respectively.

### TIME TO CRITERION--MICROFICHE VERSUS PAPER COPY

Mean times to complete the entire BE&E curriculum using microfiche and paper copy are presented by aptitude category in table 1.

TABLE 1. MEAN TIME TO COMPLETE BE&E CURRICULUM (HOURS)

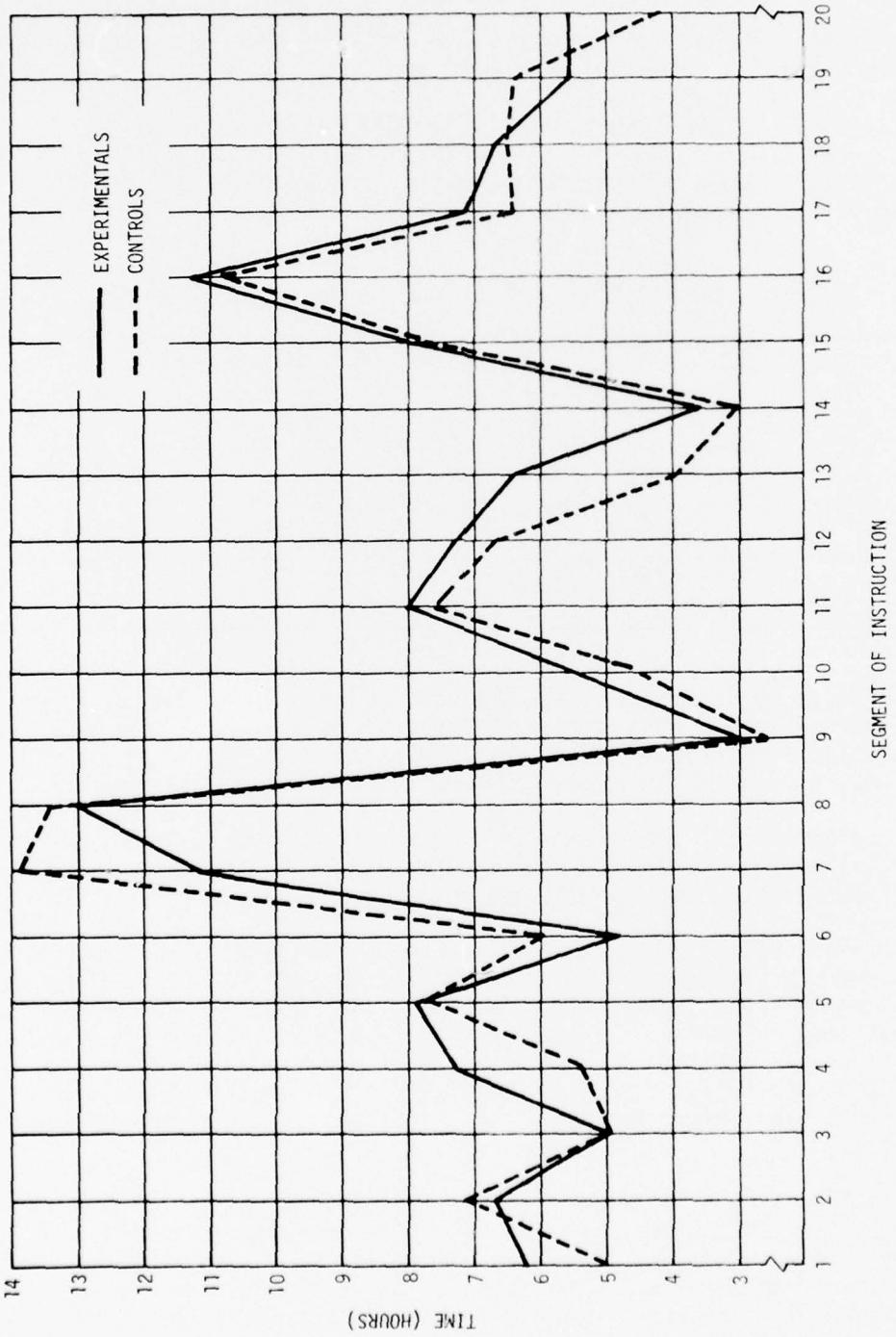
| | APTITUDE | | | | | |
|---|---|---|---|---|---|---|
| | HIGH | | MEDIUM | | LOW | |
| | Mean | SD | Mean | SD | Mean | SD |
| MICROFICHE | 113.45 | 23.48 | 125.86 | 38.85 | 182.69 | 42.68 |
| PAPER COPY | 112.45 | 27.48 | 145.79 | 26.19 | 142.60 | 46.41 |

The effects of segment of instruction, aptitude, and medium on time to criterion were examined by a three-way analysis of variance. The analysis revealed a significant ($p < .01$) effect of aptitude. In general, the lower the aptitude, the longer the time required to complete the curriculum.

The performance of the low and medium aptitude groups using paper copy was essentially equivalent. The limited ability of aptitude scores to predict individual performance may account for this.

The overall effect of medium on performance was not significant at the .05 level; however, a significant ($p < .02$) Interaction (Medium X Aptitude) was found. A Neuman-Keuls (Winer, 1962) analysis indicated that under the condition of low aptitude, trainees using microfiche required a significantly greater amount of time to complete the curriculum. It would appear from table 1 that trainees using microfiche performed better than the control group under the medium aptitude condition; however, this difference was not significant at the .05 level.

A significant ($p < .01$) effect of segment of instruction (figure 1) was found, indicating that some segments of instruction were more difficult (i.e., required more time) than others. This is considered to be common knowledge and is an inherent characteristic of the curriculum. Three Interactions--Medium X Segment, Aptitude X Segment, and Medium X Aptitude X Segment--were not significant at the .05 level.


EXPERIMENTALS
CONTROLS
TIME (HOURS)
SEGMENT OF INSTRUCTION
14
13
12
11
10
9
8
7
6
5
4
3
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

EXAMINATION ERRORS--MICROFICHE VERSUS PAPER COPY

The effects of aptitude and medium on comprehensive examination errors (figure 2) were examined by a two-way analysis of variance. This analysis considered the combined errors on the midpoint (increment #9) and final (increment #20) examinations. A significant ($p < .01$) effect of aptitude indicated that higher aptitude trainees made fewer errors than lower aptitude trainees. The effect of medium and the Interaction (Aptitude X Medium) were not significant at the .05 level.

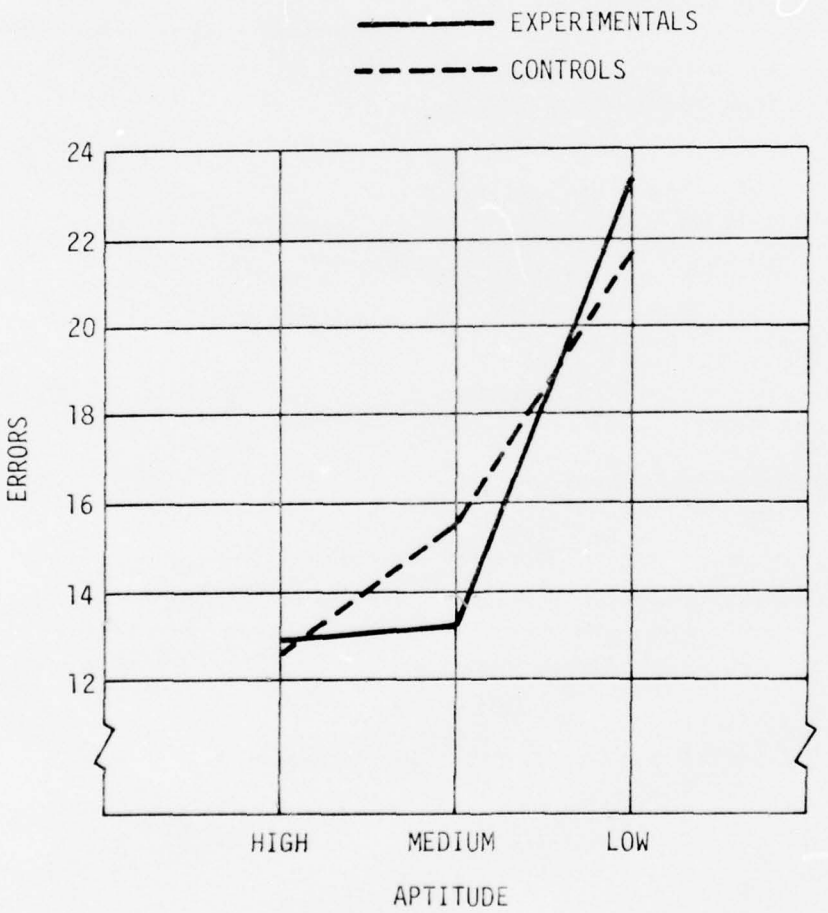



Figure 2. Mean Combined Errors on Comprehensive Examinations

INTERVIEW RESPONSES

At the conclusion of training, each microfiche trainee was interviewed by the experimenter. The structure and content of the interview can be found in appendix C. Frequency of response to interview questions is presented in table 2, by aptitude group. In general, interview responses were positive, in favor of the microfiche medium. The data in table 2 are presented for information, only. No statistical analysis was performed on individual interview items due to the similarity of responses and the small number (10) in each group. Section IV contains a summary of trainee comments and recommendations.

TABLE 2. INTERVIEW RESPONSE FREQUENCIES

| NO. | OPERATIONAL FACTORS | | H | M | L |
|---|---|---|---|---|---|
| 1. | Did you have any problems in selecting the correct microfiche module from the storage folder? | Yes | 0 | 0 | 0 |
| | | No | 10 | 10 | 10 |
| 2. | Did you have any problems in loading or unloading microfiche? | Yes | 0 | 0 | 0 |
| | | No | 10 | 10 | 10 |
| 3. | Did you have any problems locating the correct microfiche pages using the reader index? | Yes | 0 | 1 | 0 |
| | | No | 10 | 9 | 10 |
| 4. | Did you have any problems in focusing the microfiche reader lens? | Yes | 0 | 0 | 0 |
| | | No | 10 | 10 | 10 |
| 5. | Did you experience any microfiche reader equipment failures? | Yes | 3 | 3 | 2 |
| | | No | 7 | 7 | 8 |
| | MICROFICHE TRAINING MODULES | | | | |
| 6. | Was the legibility of the microfiche text adequate? | Yes | 9 | 10 | 10 |
| | | No | 1 | 0 | 0 |
| 7. | Was the legibility of the microfiche illustrations adequate? | Yes | 9 | 8 | 10 |
| | | No | 1 | 2 | 0 |
| 8. | Have you ever used programmed instruction before? | Yes | 2 | 2 | 2 |
| | | No | 8 | 8 | 8 |
| 9. | How often did you use the narrative sections of the modules? | Never | 0 | 0 | 0 |
| | | Seldom | 0 | 0 | 0 |
| | | Occasionally | 0 | 0 | 0 |
| | | Frequently | 0 | 3 | 0 |
| | | Always | 10 | 7 | 10 |

TABLE 2. INTERVIEW RESPONSE FREQUENCIES (continued)

| NO. | MICROFICHE TRAINING MODULES (continued) | | H | M | L |
|---|---|---|---|---|---|
| 10. | How often did you use the programmed instruction section of the modules? | Never | 2 | 1 | 0 |
| | | Seldom | 3 | 2 | 1 |
| | | Occasionally | 0 | 3 | 4 |
| | | Frequently | 4 | 3 | 2 |
| | | Always | 1 | 1 | 3 |
| 11. | How often did you use the summary sections of the modules? | Never | 0 | 0 | 1 |
| | | Seldom | 4 | 0 | 3 |
| | | Occasionally | 1 | 2 | 2 |
| | | Frequently | 3 | 2 | 2 |
| | | Always | 2 | 6 | 2 |
| 12. | How often did you use the enrichment materials for the modules? | Never | 0 | 0 | 0 |
| | | Seldom | 10 | 8 | 6 |
| | | Occasionally | 0 | 2 | 1 |
| | | Frequently | 0 | 0 | 3 |
| | | Always | 0 | 0 | 0 |
| 13. | List the sequence in which you typically used the narrative, programmed instruction, summary, and enrichment materials. | NPSE | 3 | 6 | 5 |
| | | NSPE | 5 | 3 | 1 |
| | | NEPS | 0 | 0 | 1 |
| | | NPES | 0 | 0 | 3 |
| | | NSE | 2 | 1 | 0 |
| | PHYSICAL COMFORT | | | | |
| 14. | How much eyestrain did you experience using microfiche compared to printed paper? | More | 0 | 1 | 3 |
| | | Less | 4 | 4 | 3 |
| | | Same | 6 | 5 | 4 |
| 15. | How much body fatigue did you experience using microfiche? | More | 1 | 2 | 1 |
| | | Less | 6 | 5 | 3 |
| | | Same | 3 | 3 | 6 |
| 16. | Did you experience any problems shifting your attention from the microfiche reader to equipment or answer sheets? | Yes | 0 | 0 | 1 |
| | | No | 10 | 10 | 9 |
| 17. | Were there any more distractions using microfiche compared to printed paper? | Yes | 4 | 2 | 3 |
| | | No | 6 | 8 | 7 |

TABLE 2. INTERVIEW RESPONSE FREQUENCIES (continued)

| NO. | STUDY HABITS | | H | M | L |
|---|---|---|---|---|---|
| 18. | Were you able to study just as long at one sitting using microfiche compared to books? | Yes | 9 | 9 | 9 |
| | | No | 1 | 1 | 1 |
| 19. | Would you have studied differently using the printed modules? | Yes | 7 | 7 | 7 |
| | | No | 3 | 3 | 3 |
| 20. | Were there any inconveniences using microfiche that you would not have experienced using the printed modules? | Yes | 3 | 9 | 3 |
| | | No | 7 | 1 | 7 |
| | ATTITUDES | | | | |
| 21. | Have you used any kind of microfilm before? | Yes | 7 | 2 | 3 |
| | | No | 3 | 8 | 7 |
| 22. | What was your attitude toward using microfiche when you began the BE&E course? | Positive | 8 | 7 | 6 |
| | | Negative | 1 | 0 | 1 |
| | | No Opinion | 1 | 3 | 3 |
| 23. | Did your attitude toward using microfiche change after you had worked with it for awhile? | More Positive | 2 | 2 | 3 |
| | | More Negative | 0 | 2 | 2 |
| | | No change | 8 | 6 | 5 |
| 24. | Would you prefer to use microfiche or books in a similar course using programmed instruction? | Microfiche | 7 | 6 | 5 |
| | | Books | 2 | 2 | 3 |
| | | No Preference | 1 | 2 | 2 |
| | RECOMMENDATIONS | | | | |
| 25. | What recommendations would you make for improving programmed instruction on microfiche? | Made Recom. | 4 | 4 | 5 |
| | | Made No Recom. | 6 | 6 | 5 |
| | OTHER COMMENTS | | | | |
| 26. | Is there anything else you would like to comment on that I haven't asked you about? | Made Comments | 5 | 4 | 1 |
| | | Made No Comments | 5 | 6 | 9 |

To compare the overall attitudes of the three aptitude categories, an analysis of variance was performed on the number of positive responses by the three groups to questions 1, 2, 3, 4, 6, 7, 14, 15, 17, 18, 19, 20, 24, and the net positive value of 22/23. For this analysis, a positive response was defined as one which reflected favorably on the microfiche medium with regard to operational factors, training modules, physical comfort, study habits, and attitudes. Differences in numbers of positive responses (table 3) across aptitude categories were not statistically significant.

TABLE 3. MEAN POSITIVE RESPONSES TO INTERVIEW QUESTIONS

| APTITUDE | | |
|---|---|---|
| HIGH | MEDIUM | LOW |
| 12.3 | 11.4 | 11.6 |
| Maximum Possible = 15 | | |

# SECTION IV

# DISCUSSION

## PERFORMANCE

The experimental results suggest that, overall, there were no differences in school performance between subjects trained with microfiche and those trained with traditional paper copy. However, the 28 percent performance differential between those media for low aptitude trainees may be cause for concern. For reasons not clearly evident from the data, the microfiche trainees in this category required substantially more time to complete the curriculum.

This may be explained in terms of differential adaptability. It is common to find the characteristic of adaptability in definitions of intelligence. For example, intelligence has been defined as, "...general mental ability, especially the ability to think rationally, use memory and knowledge, and adapt to new situations" (Psychology '73-'74, 1973). Given that the ASVAB scores used as predictor variables in this study are a form of intelligence measure, it is apparent from scores on both dependent variables (time and errors) that intelligence is related to performance in BE&E training; i.e., the higher the ASVAB scores, the lower the number of errors and time to criterion. The analysis of variance results were further supported by the correlational relationships between the ASVAB scores and performance. The Pearson Product Moment Correlations between ASVAB scores and performance criteria are presented in table 4.

TABLE 4. CORRELATION OF ASVAB SCORES WITH TIME AND ERRORS

| | MICROFICHE | PAPER COPY |
|---|---|---|
| TIME TO CRITERION | -.6513 | -.3411 |
| ERRORS | -.5463 | -.3899 |

The differential performance of the experimental and control groups may be attributed to the adaptability component of intelligence. That is, when faced with a new learning situation, the low ASVAB/microfiche trainees experienced difficulty in adapting. This inability to adapt appears to be a subtle, yet constant effect based on two observations: (1) the subjects in question did not report such difficulty in the posttraining interview and (2) differences in performance scores (between treatment groups) did not vary systematically; i.e., differences did not diminish as training progressed.

Some support for these results is found in previous research dealing with microfiche. Kottenstette (1969) found in a reading experiment, "...no fundamental physical or psychological barriers to the utilization of microforms in the communication of information that the student customarily encounters in hardcopy." The Kottenstette study used college students as subjects, comparable in academic aptitude to the high and, perhaps, medium groups in the BE&E study. Similar results indicating no differences between microfiche and hardcopy have been reported by Gaddy (1971) and Grausnick (1971).

Baldwin and Bailey (1971) investigated the effects of microfiche versus paper copy using performance scores on tests of 12 cognitive skills. Using Air Force trainees as subjects, they found that three skills were performed more effectively using paper copy--graph interpretation, figure identification, and symbol translation. These kinds of tasks are an integral part of BE&E training.

In a replication of this study, Grausnick and Kottenstette (1971) compared Air Force trainees divided into high, medium, and low intelligence groups. Their results reflected the results of the Baldwin and Bailey study with superior performance on two additional tasks using paper copy--length estimation and table lookup. It was found that the lower intelligence group was adversely affected by the microfiche mode of presentation. The lower intelligence subjects using paper copy performed better than microfiche subjects on one additional task--a narrative reading exercise. These authors concluded that, "...these differences suggest a possible limitation for training applications for students in lower intelligence groups using microfiche equipment." The importance of this finding is also apparent from the results of the BE&E study. The low aptitude group in this study represents approximately 20-25 percent of the BE&E School population. If this group reliably averages 28 percent more training time using microfiche, the costs will be profound.

## ATTITUDES

The posttraining interview was designed to solicit responses regarding operational factors, microfiche training modules, physical comfort, study habits, attitudes, and recommendations. In addition to answering direct questions, the subjects were encouraged to comment freely on any topic related to the experiment. There was no notable trend in the unsolicited remarks; however, comments made by two or more subjects are summarized and paraphrased as follows:

- an index is needed at the beginning of each module
- illustrations of test meter dials were illegible
- the reader parts had to be cleaned frequently to maintain the quality of the projected image
- the microfiche medium captured attention
- the reader fan noise was a distraction
- study habits were limited by the lack of reader portability
- the programmed instruction questions and answers should be more spatially separated
- the vertical presentation of the reader facilitated secondary tasks such as writing and performing calculations.

The subjective response of users to microfiche as a training medium is not unique to this investigation. Similar positive results have been documented in prior studies (Kottenstette, 1969; Grausnick, 1971; Gaddy, 1971; Keeler and Rizzo, 1976; Rizzo, 1977). It is reasonable to conclude from this evidence that minimal resistance may be expected in introducing microfiche as an instructional delivery system.

# SECTION V

# COST ANALYSES

The comparative cost analyses presented in this section reflect existing and hypothetical media configurations encompassing four BE&E training facilities--Orlando, Memphis, Great Lakes, and San Diego. While the feasibility of using microfiche for BE&E training was not the focus of the study, the cost analyses are presented to illustrate the efficiency of an alternative instructional delivery system.

Costs illustrated are limited to those directly related to the paper or microfiche medium, as opposed to total costs of training. This limitation necessitates numerous assumptions as well as caveats. These ground rules are described in terms of those applicable to all alternatives and those which are alternative-specific.

## GENERAL ASSUMPTIONS

1. Total BE&E annual throughput, by rating, is based on CNET Report 1500.1121, for the period 30 September 1975 through 1 October 1976. Throughput is assumed to be 20,000 (rounded from 19,895) per year. The average number of modules used per trainee across all ratings is 16.

2. The Planning Period is 10 years.

3. A discount rate of 10 percent was used to compute Present Cost of each alternative. The discount rate is the interest rate used in calculating the present value of expected yearly costs and benefits. It represents the accepted price of money or the interest rate currently obtainable on loanable funds. For example, the present value of $100 payable in 5 years can be defined as the amount of money necessary to invest today in order to have $100 in 5 years.

4. Costs illustrated are based on constant dollars; i.e., costs have not been adjusted for inflation. If it is anticipated that inflation will have a differential impact on the cost of the alternatives, then adjustments should be made when costing alternatives for future planning.

5. Existing supplies of instructional materials will be consumed prior to the beginning of the Planning Period.

6. The rate of consumption of instructional materials will vary as a function of differential handling and fiscal austerity. Therefore, costs across a range of consumption rates are illustrated. It is the normal practice of BE&E Schools to reuse instructional materials several times. However, the cost of using these materials only once is included, as this is a common mode in other Navy schools. This is not suggested as an alternative for BE&E administration, rather, it is illustrated to enable cost comparisons where individual trainees are permitted to keep their instructional materials.

7. The required ratio of test copies to throughput is 1:10. Test copies are expected to last 2 years.

8. A 10 percent backup of instructional materials and tests is required to compensate for loss or destruction.

9. Production costs of the original copy of instructional materials are equivalent across alternatives. The microfiche originals are second generation and are costed separately.

10. During the first year of the Planning Period, instructional materials will be produced in 6-month supplies to accommodate changes or refinements to content or printing. Subsequently, materials will be produced in sufficient quantity to last 1 year. The cost of updating materials across alternatives is assumed to be equivalent; however, it should be noted that the mechanics of updating offset copy and microfiche are different and may, in fact, incur differential costs. Paper updating involves retyping masters prior to reprinting, with interim changes published as errata sheets which are posted by the individual trainee. Microfiche updating involves retyping of masters as well as rephotographing. Substantial interim changes may require republishing microfiche more frequently as these changes cannot be made manually by the trainee.

11. Storage space required for paper modules and backup microfiche readers is equivalent.

12. All schools will operate in two equally manned 6-hour shifts/day, 5 days/week, 50 weeks/year.

13. The amount of home study is estimated to be 5 percent of total training time.

14. The attrition rates for trainees using microfiche and paper copy are assumed to be equivalent. However, if a portion of the trainee population has difficulty using microfiche, it may be reasonable to assume that the attrition rate for this group will be somewhat higher.

ALTERNATIVE A (Table 5)

This alternative reflects existing BE&E training using paper copy for all instruction and testing, subject to the general assumptions above. The current practice is to reuse instructional materials approximately 20 times.

ALTERNATIVE B (Table 6)

1. This alternative assumes that all BE&E instructional and testing materials have been republished as microfiche.

2. No usable microfiche readers are on hand prior to the Planning Period.

3. A 10 percent backup of microfiche readers is required to compensate for those damaged or in maintenance. A 10 percent backup of projection lamps is also required to accommodate fluctuations in lamp life.

4. The Realist/Vantage III microfiche reader is used for illustration only and is not specifically endorsed for this use. Power consumption and lamp life are manufacturer's specifications.

5. Hardware prices are GSA quantity purchase quotations.

ALTERNATIVE C (Table 7)

1. This alternative also assumes that BE&E training is accomplished using microfiche but with no adverse effects on training.

2. Microfiche readers are made available in the barracks for home study. The ratio of home study readers to average on board (AOB) is 1:3.

ALTERNATIVE D (Table 8)

1. This alternative considers using the Personalized Portable Micromedia Display System (PPMDS) as proposed by the Terminal Data Corporation. Each trainee is issued a portable reader which is used for classroom training, testing, and home study.

2. A major assumption of this alternative is that training time is not extended by using microfiche with the PPMDS reader.

DISCUSSION OF COST ANALYSES

Comparisons across alternatives may be made by examination of the Total Present Cost (tables 5, 6, 7, 8, and summary table 9). The subtotals correspond to differential rates of instructional material consumption. It is apparent that the cost of a microfiche-based instructional delivery system for BE&E training would be considerably greater than paper copy. The cost differential is greatly influenced by the additional training time required for 20 percent of the trainee population and additional time for all trainees due to denial of home study. If there are no effects of medium on training time, the cost of using microfiche would be at least twice that of paper copy.

The cost advantage of microfiche versus paper copy becomes a reality in situations where large quantities of instructional materials are expended. This is illustrated by comparing subtotals a. in tables 5, 6, 7, and 8, or line a. in table 9. This comparison is only valid, however, with the assumption that no portion of the trainee population is adversely affected by using microfiche.

These results suggest factors which must be addressed in considering the use of microfiche for onboard training. If the nature of onboard training is such that individuals study while not on watch, the personnel cost of training is essentially zero. Presumably, moderate increases in time to complete a course of instruction may be accommodated with minimal effect on readiness.

The cost of microfiche readers may be significantly reduced in the onboard training environment. The PPMDS readers being procured for this purpose are expected to cost approximately $100 each. It is anticipated that these readers will be shared among trainees, thereby further reducing hardware costs.

Perhaps the most cogent consideration in the onboard training environment is space reduction--training time and hardware costs being secondary factors. Certainly, a large volume of paper training materials may be replaced by a handful of microfiche. However, whether or not the paper would be displaced by required microfiche readers should be subject for investigation in specific situations.

TABLE 5. COST ANALYSIS OF BE&E TRAINING - ALTERNATIVE A
(CURRENT PRACTICE USING PRINTED MODULES)

| DESCRIPTION | INITIAL $ COST | USEFUL LIFE | YEARS IN PLANNING PERIOD 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL PRESENT COST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Printing Costs + 10% Training Modules | | | | | | | | | | | | | |
| a. Used 1 Time | 264,000 | 1 yr | 264,000 | 528,000 | 528,000 | 528,000 | 528,000 | 528,000 | 528,000 | 528,000 | 528,000 | 528,000 | |
| b. Used 10 Times | 26,400 | 1 yr | 26,400 | 52,800 | 52,800 | 52,800 | 52,800 | 52,800 | 52,800 | 52,800 | 52,800 | 52,800 | |
| c. Used 15 Times | 16,100 | 1 yr | 16,100 | 32,200 | 32,200 | 32,200 | 32,200 | 32,200 | 32,200 | 32,200 | 32,200 | 32,200 | |
| d. Used 20 Times | 13,200 | 1 yr | 13,200 | 26,400 | 26,400 | 26,400 | 26,400 | 26,400 | 26,400 | 26,400 | 26,400 | 26,400 | |
| e. Used 25 Times | 10,560 | 1 yr | 10,560 | 21,120 | 21,120 | 21,120 | 21,120 | 21,120 | 21,120 | 21,120 | 21,120 | 21,120 | |
| Tests | 19,980 | 2 yrs | | | 19,980 | | 19,980 | | 19,980 | | 19,980 | | |
| TOTALS | | | | | | | | | | | | | |
| a. Used 1 Time | 283,980 | | 264,000 | 528,000 | 547,980 | 528,000 | 547,980 | 528,000 | 547,980 | 528,000 | 547,980 | 528,000 | a. $3,486,979 |
| b. Used 10 Times | 46,380 | | 26,400 | 52,800 | 72,780 | 52,800 | 72,780 | 52,800 | 72,780 | 52,800 | 72,780 | 52,800 | b. 410,286 |
| c. Used 15 Times | 36,080 | | 16,100 | 32,200 | 52,180 | 32,200 | 52,180 | 32,200 | 52,180 | 32,200 | 52,180 | 32,200 | c. 276,910 |
| d. Used 20 Times | 33,180 | | 13,200 | 26,400 | 46,380 | 26,400 | 46,380 | 26,400 | 46,380 | 26,400 | 46,380 | 26,400 | d. 239,358 |
| e. Used 25 Times | 30,540 | | 10,560 | 21,120 | 41,100 | 21,120 | 41,100 | 21,120 | 41,100 | 21,120 | 41,100 | 21,120 | e. 205,173 |

TABLE 6. COST ANALYSIS OF BE&E TRAINING - ALTERNATIVE B
(MODULES REPUBLISHED AS MICROFICHE)

| DESCRIPTION | INITIAL $ COST | USEFUL LIFE | YEARS IN PLANNING PERIOD 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | TOTAL PRESENT COST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Microfiche Readers/Tng | 260,429 | 5 yrs | | | | | | 260,429 | | | | | | |
| Microfiche Readers/Test | 26,026 | 5 yrs | | | | | | 26,026 | | | | | | |
| Projection Lamps | | 1000 hrs | 20,711 | 31,067 | 31,067 | 31,067 | 31,067 | 20,711 | 31,067 | 31,067 | 31,067 | 31,067 | | |
| Additional Elect Power | | | 12,609 | 12,609 | 12,609 | 12,609 | 12,609 | 12,609 | 12,609 | 12,609 | 12,609 | 12,609 | | |
| Microfiche Production | | | | | | | | | | | | | | |
| Originals | 281 | | | | | | | | | | | | | |
| Copies | | | | | | | | | | | | | | |
| a. Used 1 Time | 37,720 | 1 yr | 37,720 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | | |
| b. Used 10 Times | 3,772 | 1 yr | 3,772 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | | |
| c. Used 15 Times | 2,516 | 1 yr | 2,516 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | | |
| d. Used 20 Times | 1,886 | 1 yr | 1,886 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | | |
| e. Used 25 Times | 1,509 | 1 yr | 1,509 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | | |
| Test Originals | 175 | | | | | | | | | | | | | |
| Test Copies | 5,000 | 2 yrs | | | 5,000 | | 5,000 | | 5,000 | | 5,000 | | | |
| Additional Tng Time/ Low Group | | | 1,347,480 | 1,347,480 | 1,347,480 | 1,347,480 | 1,347,480 | 1,347,480 | 1,347,480 | 1,347,480 | 1,347,480 | 1,347,480 | | |
| Additional Tng Time/ Denial of Home Study | | | 1,497,200 | 1,497,200 | 1,497,200 | 1,497,200 | 1,497,200 | 1,497,200 | 1,497,200 | 1,497,200 | 1,497,200 | 1,497,200 | | |
| TOTALS | | | | | | | | | | | | | | |
| a. Used 1 Time | 329,631 | | 2,915,670 | 2,963,796 | 2,968,796 | 2,963,796 | 2,968,796 | 3,239,895 | 2,968,796 | 2,963,796 | 2,968,796 | 2,963,796 | a. | $19,581,266 |
| b. Used 10 Times | 295,683 | | 2,881,772 | 2,895,900 | 2,900,900 | 2,895,900 | 2,900,900 | 3,171,999 | 2,900,900 | 2,895,900 | 2,900,900 | 2,895,900 | b. | 19,141,720 |
| c. Used 15 Times | 294,427 | | 2,880,516 | 2,893,388 | 2,898,388 | 2,893,388 | 2,898,388 | 3,169,487 | 2,898,388 | 2,893,388 | 2,898,388 | 2,893,388 | c. | 19,125,456 |
| d. Used 20 Times | 293,797 | | 2,879,886 | 2,892,128 | 2,897,128 | 2,892,128 | 2,897,128 | 3,168,227 | 2,897,128 | 2,892,128 | 2,897,128 | 2,892,128 | d. | 19,117,298 |
| e. Used 25 Times | 293,420 | | 2,879,509 | 2,891,374 | 2,896,374 | 2,891,374 | 2,896,374 | 3,167,473 | 2,896,374 | 2,891,374 | 2,896,374 | 2,891,374 | e. | 19,112,416 |

TABLE 7. COST ANALYSIS OF BE&E TRAINING - ALTERNATIVE C
(MODULES REPUBLISHED AS MICROFICHE - NO INCREASE IN TRAINING TIME)

| DESCRIPTION | INITIAL $ COST | USEFUL LIFE | YEARS IN PLANNING PERIOD 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL PRESENT COST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Microfiche Readers/Tng | 392,756 | 5 yrs | | | | | | 392,756 | | | | | |
| Microfiche Readers/Test | 23,660 | 5 yrs | | | | | | 23,660 | | | | | |
| Projection Lamps | | 1000 hrs | 18,722 | 28,090 | 28,090 | 28,090 | 28,090 | 18,722 | 28,090 | 28,090 | 28,090 | 28,090 | |
| Additional Elect Power | | | 11,970 | 11,970 | 11,970 | 11,970 | 11,970 | 11,970 | 11,970 | 11,970 | 11,970 | 11,970 | |
| Microfiche Production Originals | 281 | | | | | | | | | | | | |
| Copies | | | | | | | | | | | | | |
| a. Used 1 Time | 37,720 | 1 yr | 37,720 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | |
| b. Used 10 Times | 3,772 | 1 yr | 3,772 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | |
| c. Used 15 Times | 2,516 | 1 yr | 2,516 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | |
| d. Used 20 Times | 1,886 | 1 yr | 1,886 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | |
| e. Used 25 Times | 1,509 | 1 yr | 1,509 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | |
| Test Originals | 175 | | | | | | | | | | | | |
| Test Copies | 5,000 | 2 yrs | | | 5,000 | | 5,000 | | 5,000 | | 5,000 | | |
| TOTALS | | | | | | | | | | | | | |
| a. Used 1 Time | 459,592 | | 68,412 | 115,500 | 120,500 | 115,500 | 120,500 | 522,548 | 120,500 | 115,500 | 120,500 | 115,500 | a. $1,413,208 |
| b. Used 10 Times | 425,644 | | 34,464 | 47,604 | 52,604 | 47,604 | 52,604 | 454,652 | 52,604 | 47,604 | 52,604 | 47,604 | b. 973,614 |
| c. Used 15 Times | 424,388 | | 33,208 | 45,092 | 50,092 | 45,092 | 50,092 | 452,140 | 50,092 | 45,092 | 50,092 | 45,092 | c. 957,350 |
| d. Used 20 Times | 423,758 | | 32,578 | 43,832 | 48,832 | 43,832 | 48,832 | 450,880 | 48,832 | 43,832 | 48,832 | 43,832 | d. 949,192 |
| e. Used 25 Times | 423,381 | | 32,201 | 43,078 | 48,078 | 43,078 | 48,078 | 450,125 | 48,078 | 43,078 | 48,078 | 43,078 | e. 944,309 |

TABLE 8. COST ANALYSIS OF BE&E TRAINING - ALTERNATIVE D
(MODULES REPUBLISHED AS MICROFICHE - PPMDS)

| DESCRIPTION | INITIAL $ COST | USEFUL LIFE | YEARS IN PLANNING PERIOD 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL PRESENT COST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Microfiche Readers | 278,000 | 5 yrs | | | | | | 278,000 | | | | | |
| Projection Lamps | | 200 hrs | 4,876 | 5,586 | 5,586 | 5,586 | 5,586 | 4,876 | 5,586 | 5,586 | 5,586 | 5,586 | |
| Additional Elect Power | | | 5,985 | 5,985 | 5,985 | 5,985 | 5,985 | 5,985 | 5,985 | 5,985 | 5,985 | 5,985 | |
| Microfiche Production | | | | | | | | | | | | | |
| Originals | 281 | | | | | | | | | | | | |
| Copies | | | | | | | | | | | | | |
| a. Used 1 Time | 37,720 | 1 yr | 37,720 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | 75,440 | |
| b. Used 10 Times | 3,772 | 1 yr | 3,772 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | 7,544 | |
| c. Used 15 Times | 2,516 | 1 yr | 2,516 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | 5,032 | |
| d. Used 20 Times | 1,886 | 1 yr | 1,886 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | 3,772 | |
| e. Used 25 Times | 1,509 | 1 yr | 1,509 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | 3,018 | |
| Test Originals | 175 | | | | | | | | | | | | |
| Test Copies | 5,000 | 2 yrs | | | 5,000 | | 5,000 | | 5,000 | | 5,000 | | |
| TOTALS | | | | | | | | | | | | | |
| a. Used 1 Time | 321,176 | | 48,581 | 87,011 | 92,011 | 87,011 | 92,011 | 364,301 | 92,011 | 87,011 | 92,011 | 87,011 | a. $1,022,344 |
| b. Used 10 Times | 287,228 | | 14,633 | 19,115 | 24,115 | 19,115 | 24,115 | 296,405 | 24,115 | 19,115 | 24,115 | 19,115 | b. 582,750 |
| c. Used 15 Times | 285,972 | | 13,377 | 16,603 | 21,603 | 16,603 | 21,603 | 293,893 | 21,603 | 16,603 | 21,603 | 16,603 | c. 566,486 |
| d. Used 20 Times | 285,342 | | 12,747 | 15,343 | 20,343 | 15,343 | 20,343 | 292,633 | 20,343 | 15,343 | 20,343 | 15,343 | d. 558,328 |
| e. Used 25 Times | 284,965 | | 12,370 | 14,589 | 19,589 | 14,589 | 19,589 | 291,879 | 19,589 | 14,589 | 19,589 | 14,589 | e. 553,446 |

TABLE 9. SUMMARY - COST OF ALTERNATIVES

| | *ALTERNATIVES | | | |
|---|---|---|---|---|
| TRAINING MATERIALS USED | A | B | C | D |
| a. 1 Time | $3,486,979 | $19,581,266 | $1,413,208 | $1,022,344 |
| b. 10 Times | 410,286 | 19,141,720 | 973,614 | 582,750 |
| c. 15 Times | 276,910 | 19,125,456 | 957,350 | 566,486 |
| d. 20 Times | 239,358 | 19,117,298 | 949,192 | 558,328 |
| e. 25 Times | 205,173 | 19,112,416 | 944,309 | 553,446 |

*A - Current practice using printed modules

B - Modules republished as microfiche

C - Modules republished as microfiche - no increase in training time

D - Modules republished as microfiche - PPMDS

# SECTION VI

# CONCLUSIONS AND RECOMMENDATIONS

The results of this study support findings of earlier research evaluating microfiche as an instructional medium. It appears that, for the majority of students found in a typical military technical training environment, the use of microfiche vice paper copy has no effect on learning. Trainees are able to effectively use the microfiche equipment with a minimum amount of instruction and, in general, express favorable attitudes toward microfiche.

There are two major considerations in using microfiche as the primary instructional medium in Navy schools. The most critical consideration is the makeup of the trainee population with respect to aptitude. There is evidence that lower aptitude individuals experience some difficulty in cognitively extracting and/or retaining information using fiche. As this difficulty increases training time, AOB or throughput suffers accordingly. While this effect may be translated into dollar costs, the total costs must reflect required end strength and, ultimately, fleet readiness.

A second important factor which must be examined in considering the use of microfiche for training is consumption of instructional materials. In environments where trainees are permitted to retain large quantities of materials, printing costs will be considerably greater than if materials are reused. In such situations, media costs may be significantly reduced by using microfiche. Cost estimates for this factor are relatively straightforward.

It is recommended that a thorough cost analysis be performed as the primary step in considering the feasibility of using microfiche for any specific training situation. The cost analyses illustrated in this study are examples and may not include all the factors relevant to a different training context.

Information currently available enables objective decision making regarding the use of microfiche for shore-based Navy schools. However, the onboard training environment offers more complex combinations and permutations of variables--some not readily quantifiable. For example, where space economy is mandatory, dollar costs may become insignificant. Where there is a liberal amount of time for training, adverse effects of the medium on training time may be insignificant.

It is recommended that the less tangible variables peculiar to the onboard (shipboard as well as onsite) environment be examined in detail to assess the total economic impact of training using the PPMDS/microfiche mode of instruction.

The planned replication of this study by TAEG using the PPMDS will give further insights regarding the capabilities and limitations of this reader. However, it is recommended that the PPMDS be ultimately evaluated in shipboard use to examine factors which may be unique to this environment.

## REFERENCES

Baldwin, T. S. and Bailey, L. J. "Readability of Technical Training Materials Presented on Microfiche Versus Offset Copy." Journal of Applied Psychology. 1971. 55, pp. 37-41.

Gaddy, D. A Research Project to Determine the Student Acceptability and Learning Effectiveness of Microform Collections in Community Junior Colleges. Phase II. Final Report. 1971. American Association of Junior Colleges, Washington, DC.

Grausnick, R. R. Microform Use in a Technical Training Environment-An Experiment. May 1971. Denver Research Institute. Denver University, CO.

Grausnick, R. R. and Kottenstette, J. P. A Performance Evaluation: Microfiche Versus Hardcopy. AFHRL-TR-71-42. May 1971. Air Force Human Resources Laboratory, Brooks AFB, TX.

Keeler, F. L. and Rizzo, W. A. An Evaluation of Microfiche Reader Types for Use with Programmed Instruction. TAEG Report No. 35. August 1976. Training Analysis and Evaluation Group, Orlando, FL.

Kottenstette, J. P. An Investigation of the Characteristics of Ultrafiche and its Application to Colleges and Universities. Interim Report. August 1969 Denver Research Institute, Denver University, CO.

Psychology '73-'74. Guilford, CT: Dushkin Publishing Group. 1973.

Rizzo, W. A. Demonstration and Evaluation of a Microfiche-Based Audio/Visual System. TAEG Technical Memorandum 77-2. April 1977. Training Analysis and Evaluation Group, Orlando, FL.

Winer, B. J. Statistical Principles in Experimental Design. (2nd ed.). New York: McGraw-Hill. 1962.

# APPENDIX A

# BE&E CURRICULUM OUTLINE

# BE&E CURRICULUM OUTLINE

Module 1

| | | |
|---|---|---|
| Lesson | I. | Electricity and the Electron |
| | II. | Electron Movement |
| | III. | Current Flow |
| | IV. | Measurement of Current |
| | V. | The Ammeter |

Module 2

| | | |
|---|---|---|
| Lesson | I. | EMF from Chemical Action |
| | II. | Magnetism |
| | III. | Electromagnetic Induction |
| | IV. | AC Voltage |
| | V. | The Uses of AC and DC |
| | VI. | Measuring Voltage |

Module 3

| | | |
|---|---|---|
| Lesson | I. | Characteristics of Resistance |
| | II. | Resistors |
| | III. | Resistor Values |
| | IV. | Ohmmeters |

Module 4

| | | |
|---|---|---|
| Lesson | I. | Measuring Current in a Series Circuit |
| | II. | Voltage in a Series Circuit |
| | III. | Using the Multimeter as a Voltmeter |

Module 5

| | | |
|---|---|---|
| Lesson | I. | Voltage, Resistance, and Current |
| | II. | The OHM's Law Formula |
| | III. | Power |
| | IV. | Internal Resistance |
| | V. | Troubleshooting Series Circuits |

Module 6

| | | |
|---|---|---|
| Lesson | I. | Rules for Voltage and Current |
| | II. | Rules for Resistance and Power |
| | III. | Variational Analysis |
| | IV. | Troubleshooting Parallel Circuits |

BE&E CURRICULUM OUTLINE (continued)

Module 7

| | | |
|---|---|---|
| Lesson | I. | Solving Complex Circuits |
| | II. | Voltage Reference |
| | III. | Voltage Dividers |

Module 8

| | | |
|---|---|---|
| Lesson | I. | Electromagnetism |
| | II. | Inductors and Flux Density |
| | III. | Inducing Voltage |
| | IV. | Inductance and Induction |

Module 9

| | | |
|---|---|---|
| Lesson | I. | Rise and Decay of Current and Voltage |
| | II. | LR Time Constant |
| | III. | Using Universal TC Chart |
| | IV. | Inductive Resistance |
| | V. | Relationship in Inductive Circuits |
| | VI. | Phase Relationships |

Module 10

| | | |
|---|---|---|
| Lesson | I. | Transformer Construction |
| | II. | Transformer Theory and Operation |
| | III. | Turns and Voltage Ratio |
| | IV. | Power and Current |
| | V. | Transformer Efficiency |
| | VI. | Semiconductor Rectifiers |

Module 11

| | | |
|---|---|---|
| Lesson | I. | The Capacitor |
| | II. | Theory of Capacitance |
| | III. | Total Capacitance |
| | IV. | RC Time Constant |
| | V. | Capacitive Reactance |
| | VI. | Phase and Power Relationships |
| | VII. | Capacitor Design Considerations |

Module 12

| | | |
|---|---|---|
| Lesson | I. | Voltage and Impedance in AC Series Circuits |
| | II. | Vector Computations |
| | III. | Rectangular and Polar Notation |
| | IV. | Variational Analysis of Series RL Circuits |
| | V. | Frequency Discrimination in RL Circuits |
| | VI. | Series RC Circuits |

BE&E CURRICULUM OUTLINE (continued)

Module 13

Lesson I. Solving RLC Circuits
II. Resonant Frequency in Series Circuits
III. Conditions of Series Resonance
IV. Experiments with Series Resonance

Module 14

Lesson I. Solving for Quantities in RL Parallel Circuits
II. Variational Analysis of RL Parallel Circuits
III. Parallel RC and RLC AC Circuits
IV. Parallel Resonance
V. Effective Resistance in Parallel RL Circuits
VI. Parallel Resonance Experiment

# APPENDIX B

# INSTRUCTIONS TO SUBJECTS

TAEG Report No. 48

# INSTRUCTIONS TO SUBJECTS

A decision has been made by the Navy to put certain instructional materials on microfiche film instead of the usual books and paper. The two major reasons for using microfiche are greatly reduced cost and storage space. It is estimated that the Navy can save millions of dollars annually by going to microfiche. A single microfiche film like you will be using can contain 98 pages of information, and a stack the size of a shoebox could contain over 200,000 pages of information.

The core of the Basic Electricity and Electronics curriculum consists of 14 modules of instruction. Throughout these modules are sections called programmed instruction. In these sections you will study a segment of information followed by a short, self-administered quiz. You will be instructed to either continue on to the next section or review the previous section, depending on how well you do in the quiz. Page numbers of the modules have been replaced with microfiche page designators, consisting of a letter and a number. The instructor will now show you a sample microfiche which has examples of indexing instructions using this system.

This microfiche is a photographic miniature of 96 printed pages. There are 14 columns of pages, numbered 1 through 14, left to right. There are seven rows of pages, lettered A through G, top to bottom. Each page has a letter and number designator. For example, page B3 would be the second row down and the third column across.

In order to use the microfiche film, a special microfiche reader, like the one in front of you, is required. To view the microfiche, the reader is used to magnify the microfiche pages and project them onto the viewing screen. The instructor will point out the main parts of the reader in front of you--the viewing screen, the lens, the microfiche carrier, and the index.

To load the microfiche into the reader, pull the carrier toward you until the upper glass opens and the carrier stops. The glass plates will remain open for microfiche loading. Hold the microfiche in front of you so the title may be read. Insert the microfiche face down between the glass plates with the title strip closest to you. Place the microfiche all the way to the back right-hand side of the carrier. Push the carrier in to close the upper glass.

The index card below and to the left of the carrier contains 98 spaces which correspond to the microfiche pages. To find a designated microfiche page, move the reference pointer attached to the carrier to the desired space on the index card. This will approximately center the desired microfiche page. Using the index pointer, find page A3.

A sharp clear image is achieved by applying a slight downward pressure while turning the lens focus ring. The reader may require refocusing periodically. Take time, now, to practice loading, unloading, and focusing the first practice microfiche.

There are 96 exposed pages on each microfiche. Each page has a letter and number designator at the top and either the word "END" or some instructions, such as "Go to B3" near the center of the page. When the instructor tells you to begin, load the sample microfiche, find page A3, focus, and begin following the instructions. The last instruction on the microfiche will bring you to a page marked "END." Then load the next sample microfiche, find page A3, focus, and begin following the instructions. The instructor will answer any questions before you begin.

The purpose of this instruction was to familiarize you with the microfiche indexing system and the reader that you will be using throughout the Basic Electricity and Electronics curriculum. The instructor will now show you a sample of Module I in booklet and microfiche formats. You will notice that the only difference between the two is the page numbering system. The instructor will answer any questions at this time.

# APPENDIX C

# BE&E EXIT INTERVIEW

TAEG Report No. 48

BE&E EXIT INTERVIEW

Name _____

Age _____

Wear glasses _____ contacts _____ for school work?

The purpose of this interview is to discuss your experience and opinions concerning the use of microfiche in the BE&E course. This information will remain strictly confidential and will not become part of your military records.

OPERATIONAL FACTORS

1. Did you have any problems in selecting the correct microfiche module from the storage folder? Yes _____ No _____ Explain _____

_____

_____

2. Did you have any problems in loading or unloading microfiche? Yes _____ No _____ Explain _____

_____

_____

3. Did you have any problems locating the correct microfiche pages using the reader index? Yes _____ No _____ Explain _____

_____

_____

4. Did you have any problems in focusing the microfiche reader lens? Yes _____ No _____ Explain _____

_____

_____

5. Did you experience any microfiche reader equipment failures? Yes _____ No _____ Explain _____

_____

_____

MICROFICHE TRAINING MODULES

6. Was the legibility of the microfiche text adequate? Yes _____

No _____ Explain _____

_____

_____

7. Was the legibility of the microfiche illustrations adequate? Yes

_____ No _____ Explain _____

_____

_____

8. Have you ever used programmed instruction before? Yes _____ No _____

9. How often did you use the narrative sections of the modules?

Never _____ Seldom _____ Occasionally _____ Frequently _____ Always _____

10. How often did you use the programmed instruction sections of the modules? Never _____ Seldom _____ Occasionally _____ Frequently ____ Always _____

11. How often did you use the summary sections of the modules? Never _____

Seldom _____ Occasionally _____ Frequently _____ Always _____

12. How often did you use the enrichment materials for the modules?

Never _____ Seldom _____ Occasionally _____ Frequently _____ Always _____

13. List the sequence in which you typcially used the narrative, programmed instruction, summary, and enrichment materials. _____

_____

_____

PHYSICAL COMFORT

14. How much eyestrain did you experience using microfiche compared to printed paper? More _____ Less _____ Same _____ Explain _____

_____

_____

15. How much body fatigue did you experience using microfiche compared to printed paper? More _____ Less _____ Same _____ Explain _____

_____

_____

16. Did you experience any problems shifting your attention from the microfiche reader to equipment or answer sheets? Yes _____ No _____ Explain _____

_____

_____

17. Were there any more distractions using micofiche compared to printed paper? Yes _____ No _____ Explain _____

_____

_____

STUDY HABITS

18. Were you able to study just as long at one sitting using microfiche compared to books? Yes _____ No _____ Explain _____

_____

_____

19. Would you have studied differently using the printed modules? Yes _____ No _____ Explain _____

_____

_____

20. Were there any inconveniences using microfiche that you would not have experienced using the printed modules? Yes _____ No _____ Explain

_____

_____

ATTITUDES

21. Have you used any kind of microfilm before? Yes _____ No _____ Explain _____

_____

22. What was your attitude toward using microfiche when you began the BE&E course? Positive _____ Negative _____ No Opinion _____

23. Did your attitude toward using microfiche change after you had worked with it for awhile? More Positive _____ More Negative _____ No Change _____

24. Would you prefer to use microfiche or books in a similar course using programmed instruction? Microfiche _____ Books _____ No Preference _____

RECOMMENDATIONS

25. What recommendations would you make for improving programmed instruction on microfiche? _____

_____

_____

_____

_____

OTHER COMMENTS

26. Is there anything else you would like to comment on that I haven't asked you about? _____

_____

_____

_____

_____

TAEG Report No. 48

DISTRIBUTION LIST

Air Force

AFHRL, Brooks AFB, TX
AFHRL, Lowry AFB, CO (TTTS, Dr. R. Burkett; TT, Library)
AFHRL, WPAFB, OH (Mr. J. Kiesch; Mr. R. Johnson)
HQ, AFLC, WPAFB, OH (ASD/SMA, COL. J. Ostrominski; ASD/SMA, Mr. J. Hyson; LOLMP, Mr. M. Delisio; PRAM, Mr. W. Wiser)
HQ ATC/TTRT, Randolph AFB, TX (Mr. W. N. Allbright)
HQ USAF/DAYX (Miss M. Bishop)
HQ USAF/DPPT (MAJ T. Chasse)
HQ USAF (LGYE, Mr. R. Welsh)
AMC (MA-SM4, Mr. R. Graves)

Army

ARI (Dr. J. Ward, Dr. R. Canter, Dr. E. Johnson)
ARMY HEL (AMXHE HEL, Mr. D. S. Mackey)
ATTNG-ITD (Mr. T. R. Simmons)
ATTNG-TA-ES (Dr. Longo)
ATTNG-TC-IT (COL R. P. Dirmeyer)
ATTNG-TMI (COL F. A. Hart)
Commandant Ordnance & Chemical School
DCA (Code 730, MAJ A. Beim)
DCS Training (ATTNG)
Defense Systems Mgt College (Library)
HQDA (DAAG-AMS-M, H. Greenhalgh and P. Allison), Washington, D.C.
ITDT Prog. Office (DARCOM, COL Cook)
Project Mgr. (ARTADS), Ft. Monmouth, NJ
Training Development Institute, Ft. Eustis (R. Spangenberg)
U.S. Army Adminstration Center (ATZI-S-MICRO, MAJ T. Wilder) Ft. Harrison, IN
USA/LEA (DALO-ILP, Mr. L. Morrett)
U.S. Army Maintenance Mgmt. Center, Lexington, KY (DRXMD-EP, Mr. R. Biliter and Mr. G. Crone; AMXMD-EP, Mr. R. Post and Mr. A. Rulon)
USA Transportation School, Ft. Eustis (Mr. Vassos)
U.S. Army Training Support Center (ATTSC-CT-MA, R. J. Maitz) Ft. Eustis, VA

Navy

BE&E Schools (Great Lakes, Orlando, Memphis, San Diego)
BUPERS (Pers 212, 22, 23)
CINCLANTFLT (Code NFM3, 04, 047)
CINCPACFLT (Code 431)
CNATRA (F. Schufletowski)
CNAVRES (Code 02)
CNET (01, 00A, N-5 (6 copies))
CNO (NOP-01C; NOP-09B1, CAPT Zettel; NOP-09B17, Mr. W. McLaughlin; NOP-29; NOP-320; NOP-39; NOP-401G, Mr. B. Gruber; NOP-514; NOP-592; NOP-987P6, Mr. H. Cheng; NOP-987P10, Dr. R. Smith; NOP-991B, Mr. M. Malehorn; NOP-991C1, Mr. D. Thurman)
CNTECHTRA (0161, Dr. N. Kerr (5 copies))
COMNAVAIRLANT (Code 50)

DISTRIBUTION LIST (continued)

Navy (continued)

COMNAVAIRPAC (Code 731)
COMSUBLANT (Code 40)
COMSUBPAC (Code 40)
COMNAVSURFLANT (Code N31, N42, N44, N64, READSUPGRU)
COMNAVSURFPAC (Code 40)
COMOPTEVFOR (Code 32, CDR Donovan)
COMTRALANT
COMTRALANT (Educational Advisor)
COMTRAPAC
CO NAVEDTRASUPPCEN NORVA
CO NAVEDTRASUPPCENPAC (Code N-1, H. Stevenson (5 copies)
CO NAVEDTRAPRODEVCEN (AH3)
CO NAVTRAEQUIPCEN (N-21, N-215, N-215 (Dr. King), N-131 (2 copies), N-2211, N-423 (R. Laugen), N-00AF, N-00M, PM TRADE)
DT NSRDC (186, S. Rainey; J. Fuller; 1863 E. Jorgensen; C. Smith; 1809.1, B. Schultz; 186A, P-721; 5321.1)
Fleet ASWTC, Norfolk, VA
Fleet Guided Missile School, Dam Neck, VA
FLTCOMBATDIRSYSTRACENLANT, Dam Neck VA
FLTCOMBATDIRSYSTRACENPAC, San Diego, CA
NATSF (00, CDR Wurth; 01, Mr. F. O'Neil; 40, Mr. W. Muller)
NAVAIR (04A4, Mr. H. Keneman; 340C, Mr. D. S. Hurst; 340F, LCDR P. Chatelier)
NAVAIR TTC, Memphis, TN
Naval Ammunition Depot, McAlester (Mr. M. Mummert)
Naval War College (Library)
Naval Weather Service Facility, Pensacola (LCDR T. Fitzpatrick)
NAVELEXENGCEN SAN DIEGO (Mr. M. Gordon)
NAVELEXSYSCOM TMPO (04F)
NAVMAT (0344, Mr. I. Rubinstein; 04B, Mr. J. Genovese; 0422, Mr. W. O'Hern; NSP-2015, Mr. R. Young; NSP-20154, Mr. G. Hinzman; PM-18, Mr. S. Light)
NAVPERSRANDCEN Liaison (Code 01H)
NAVSEA (0463, Mr. W. G. Shihda; 660F, Mr. D. Baird; 6181C, Mr. S. Myers; PMS 301, CAPT Parker; PMS 403-15, Mr. T. W. Taylor; PMS 306-1, Mr. D. McCullough; PMS 389.3, CDR D. G. Crouch; PMS 396-34, Mr. G. R. Rogers)
NAVSUP (0431C, Mr. G. Bernstein; 10, Mr. H. Burby; NPPO, Mr. J. Cherny)
NPC (RD, Mr. G. Bull)
NPGS Library
NPRDC (Dr. J. Regan, Dr. T. Curran, Dr. R. Blanchard)
NSDSA (5700, Mr. K. Radcliff)
NSWC, White Oak (Code 740)
NSWSES (5001, Mr. C. Root)
NTC Great Lakes, IL (CAPT O'Malia)
NTC, Norfolk, VA
NTC, Orlando, FL
NTC, San Diego, CA (CAPT C. McDaniel; Mr. D. Lovell; PQSDG, CDR Peterson)
ONR (450, Dr. M. Farr and Dr. W. Sinaiko; 455, Dr. S. Malecki)
Recruit Training Command, NTC, Great Lakes, IL
Recruit Training Command, NTC, Orlando, FL

DISTRIBUTION LIST (continued)

Navy (continued)

Recruit Training Command, NTC, San Diego, CA
Service School Command, Great Lakes, IL
Service School Command, Orlando, FL
Service School Command, San Diego, CA
Superintendent, Naval Academy, Annapolis, MD (Chairman, Behavioral Science Dept.)

Marine Corps

CMC (LMD-1), Washington, D.C.
MCLFDC, GCD, Quantico, VA
USMCHQ (LMD-1, Mr. H. N. Maragides)
USMC (R. Doerr)

Other Government

DARPA (Dr. R. Young, Dr. H. F. O'Neil, Jr.)
DDC (12 copies)
DGSC (B. Medoff)
DLAO (Mr. T. Beck)
DLSIE (2 copies)
NBS (T. Bagg)
NSA (R55, Mr. J. C. Davis)
OASD (I&L) (WR, Mr. R. Shorey and LTC R. Grossel; MD, Mr. J. Turke; WS, Mr. J. Mittino; M&RA, Ms. B. Dunning and Mr. F. W. Suffa)
ODDR&E (COL Henry L. Taylor)
U.S. Civil Service Commission (J. M. Ferstl)
U.S. Government Printing Office (J. P. Livsey, L. R. Gulick)

Other

Anacapa Sciences, Incorporated (ATTN: Mr. W. R. Harper), Santa Barbara, CA
Applied Psychological Services (ATTN: Dr. A. I. Siegel), Wayne, PA
Bio Technology, Inc. (ATTN: Mr. T. Post), Falls Church, VA
Center for Naval Analyses (Library, Dr. H. Kanter, Mr. S. A. Horwitz)
Eastman Kodak (Mr. Charles Gabbert), Rochester, NY
Eastman Kodak (Mr. Peter C. Thorne), Indianapolis, IN
ERIC Processing and Reference Facility, Bethesda, MD (2 copies)
Executive Editor, Psychological Abstracts, American Psychological Association
Hughes Aircraft Company (ATTN: Mr. J. Connell, M-308) Ground Systems Group, Fullerton, CA
IDA (Dr. J. Orlansky)
ManTech of New Jersey (ATTN: Mr. R. Royston), Rockville, MD
National Micrographics Association (D. M. Avedon)
Stanford Research Institute (ATTN: Mr. J. Bialik), Menlo Park, CA
Telecom Systems, Inc. (ATTN: Mr. Skewis), Arlington, VA
U. of Maryland, Baltimore County (Dr. T. Powers)
U. of Missouri, Kansas City (Dr. R. P. Carver)

Other (continued)

U. of Ohio (Dr. G. Klare)
U. of Southern California (Dr. J. Rigney)
Westinghouse Corp. (ATTN: Mr. J. Box), Hunt Valley, MD